Contribution aux exercices de prospective nationale 2020-2030

*Détecteurs et instrumentation associée*

# Neutron-Gamma Detection with Li-based Scintillators

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1. **Informations générales**

**Titre : A Neutron-Gamma detector with Elpasolite Li-based Scintillators**

**Acronyme :** *ANGELIS*

**Résumé** *(max. 600 caractères espaces compris)*

*The necessity to develop novel technical solutions for neutron-gamma detection discrimination is a priority in the field of nuclear physics research due to the increasing lack of commonly used detectors as 3He or liquid scintillators. Fostered by the significant progresses made by in the development of inorganic scintillators for neutron detection, we propose to carry on an R&D activity on Li-based elpasolite scintillators for possible application in nuclear physics experiments. In particular, we intend to develop a compact neutron detector and to demonstrate its use in RIB experiments.*

***Préciser le domaine technologique*** *(plusieurs choix possibles)*

* Scintillateurs

***Préciser la motivation principale de recherche visée par la contribution :***

* R&D Détection de neutrons
* R&D Détection de gammas

1. **Description des objectifs scientifiques et techniques   
   *(1 page max incl. figures)***

*In a context where the use of liquid scintillators is constantly limited by safety regulations and the availability of 3He is at present insufficient to support the current demand for neutrons detectors, the necessity to develop a technical solution for neutron/gamma detection and discrimination stands crucial for the nuclear physics research field. Indeed nuclear structure experiments performed at radioactive ion-beam facilities in operation or under development in Europe (ALTO-RIB, SPIRAL2, SPES) and elsewhere in the world (HRIBF-RIKEN) will need optimized equipment to detect neutrons, beta and gamma rays. For this reason the possibility to use inorganic scintillators for neutron detection and spectroscopy represents a real technology break-through that has to be pursuit.*

*We are convinced of the importance of carrying on the R&D activity on Li-based scintillator detectors and, in continuity with the well-establish collaboration with the group of Franco Camera at the INFN-Sezione di Milano, we propose to develop a compact, cost-effective neutron detector based on the use of Li-enriched elpasolites scintillators and to demonstrate its use as part of the equipment in RIB experiments.*

*Indeed, the last decade witnessed significant progresses in the development of new luminescent materials with enhanced detection properties. Concerned by the possibility to use these new inorganic scintillators for applications in nuclear physics experiments, we contributed to the European projects NupNet-GANAS at first and then to the Joint Research Activity PASPAG of ENSAR2. In particular, in the latest years, we focused our attention to the arising technology of the Li-based elpasolite. These scintillators gained popularity for their remarkable n/γ pulse shape discrimination properties, making them suitable for efficient simultaneous gamma and neutron detection. As a matter of fact, they not only offer a very high light yield for gamma rays, leading to an energy resolution better than 4.5% at 662 keV, but they provide the ability to detect thermal neutrons via the n-capture reaction on Lithium [1]-[4]. Furthermore, if Chlorine is present in the crystalline structure of the scintillator, fast neutrons can be detected via the reactions 35Cl(n,p)35S and 35Cl(n,α)32P, where the energy of the outgoing proton and alpha particle scales linearly with the neutron energy [5]-[6].*

*The development of elpasolite crystals is rapidly progressing and while new crystals are occasionally introduced on the market [7], for several of them the optics production has overcome the prototype stage; the growing process of CLYC, CLLB and CLLBC, for example, is getting more and more reliable and optics with volumes interesting for nuclear physics experiments are already available. The elpasolite technology is thus mature and the possibility to develop a Li-based detector and to demonstrate its use in RIB experiments is a timely and achievable objective in the next years.*

1. **Livrables associés, calendrier et budget indicatifs (1 page max. incl. figures)**

*The main objective of the proposed activity consists in the development of a demonstrator detector based on the arising technology of the Li-based elpasolite scintillators for nuclear structure experiments. This R&D work, which will be conducted gathering together expertise in the IN2P3 and in the INFN-sezione di Milano, can be divided in five main steps:*

*- Comparative study of the elpasolite crystals concerning the available sizes, detection and PSD property, detection efficiency and cost; particular attention will be as well paid on any novel scintillator that might be introduced on the market with volume interesting for neutron and gamma detection in nuclear physics expedients – first and second year.*

*- Selection of the best-suited photo-detector to be coupled to the scintillator crystals for the specific foreseen application – first and second year.*

*- Assembly of the demonstrator detector – third year.*

*- Characterization of the demonstrator detector in a laboratory with standard neutron and gamma-emitting radioactive sources – third and fourth year.*

*- Characterization of the demonstrator detector in an in-beam campaign - fourth and fifth year.*

*Deliverables of the proposed activity will be the reports of the crystals comparative study, the construction of the demonstrator detector and the report on the demonstrator evaluation.*

*While the standard equipment and radioactive sources required to perform the proposed R&D are already available within the laboratories that participate to the project, a basic funding of 35keuros will be necessary to support the activity: 20keuros will be necessary to purchase the elements needed to assemble the demonstrator, 10keuros will be used for travelling in order to test the demonstrator in different facilities and 5 keuros will be used for prototyping and consumable.*

1. **Références**

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[4] G. Hull et al., "Detection properties and internal activity of newly developed La-containing scintillator crystals", Nucl. Inst. and Meth. A, Vol. 925, pp. 70-75 (2019)

[5] A. Giaz et al., "The CLYC-6 and CLYC-7 response to gamma-rays, fast and thermal neutrons", Nucl. Inst. and Meth. A, Vol. 810, pp. 132-139 (2016)

[6] D. Rigamonti et al., “First neutron spectroscopy measurements with a compact C7LYC based detector at EAST”, JINST 14 C09025 (2019)

[7] R. Hawrami et al., "Tl2LiYCl6:Ce a new elpasolite scintillator", IEEE Trans. Nucl. Sci., Vol. 63 Is. 6, pp. 2838-2841 (2016)